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# Device for Producing a Riveted Joint and Corresponding Rivet

The invention relates to a device for producing a riveted joint with means for firing the rivet and means for pulling the rivet as disclosed in the disclosure part of Claim 1 as well as a rivet suitable for use with this device.

Riveted joints of this type are already known and used for the joining of workpieces, especially sheets of metal, particularly when the workpieces to be joined are accessible from only one side. Typical uses of the riveted joint are the assembly of metal fittings, walls of cassettes or disk holders or border parts on insulation panels in industry and in the construction of large halls or gymnasiums. The sheet metal pieces to be joined are of a thickness of approximately 0.1 mm to approximately 3 mm, and typically approximately 0.75 mm.

For the mounting of the rivet, made up of a rivet jacket and a rivet pin guided through the rivet jacket, the workpieces are first penetrated and the rivet with rivet jacket is pressed forward and through as far as impact of the striking head of the rivet jacket on the edge of the borehole inside the borehole. For production of the riveted joint between the workpieces then with holding back of the striking head the rivet pin is drawn counter to the pressing-in direction, whereby the end of the rivet jacket lying opposite the striking head is deformed, allowing for the formation of a widened out part, so that the workpieces to be joined together are held together between the striking head and the widening out which has been produced. This type of the riveting is frequently also known as "blind riveting." EP 0 302 128 B1 discloses a tool for drawing out or setting of blind rivets. Even with use of such a tool a preliminary borehole and insertion of the blind rivet is still required.

WO 95/05255 shows a device for production of a riveted joint with pneumatically driven means for the firing of a rivet through the workpieces to be joined and pneumatically driven means for the subsequent pulling of the rivet. The means for the firing of the rivet in this case incorporate a conically tapering, hollow cylindrical driving-in part on the striking head of the rivet jacket. The rivet pin is guided through an opening in the striking surface of the driving-in part which is turned toward the striking head of the rivet in the interior of the driving-in part, and at that point is picked up by the means arranged to the rear of the driving-in part in the firing direction for the pulling of the rivet. The outlay for construction required by the arrangement of the means for the pulling of the rivet within the hollow cylindrical volume formed by the means for the firing of the rivet is considerable for such a device, especially because it requires the reliable operation of such a device while using high quality materials and also requires the maintenance of low manufacturing tolerances with reference to the means for pulling the rivet. Also this arrangement requires a large structure for the entire assembly.

The object of the present invention relates to the problem of manufacturing a device for producing a riveted joint which can be manufactured at low cost and which still guarantees reliable operation. The outlay for construction for the manufacture and preparation of means for the firing of the rivet is therefore to be held as low as possible, and a realization with smaller structural dimensions than is customary is to be possible. Also a rivet is to be developed and manufactured which can be processed using this device.

The problem is solved by the device disclosed in Claim 1. A suitable rivet is described in Claim 10. Specific embodiments of the invention are described in the dependent claims.

The problem is solved using a device as in Claim 1 in that the means for the driving-in or pulling of the rivet act on the rivet pin. Thus it is possible that the means for the pulling of the rivet

engage advantageously in the firing direction before the means for the firing of the rivet on the rivet pin. The constructive configuration showing room for some play in the realization of the means for pulling of the rivet is then more extensive and at the same time a suitable device can be realized which is small and easy to manufacture. The firing of the rivet by means of force being applied to the rivet pin also heightens the reliability of the riveted joint which is then produced, since a sure penetration of the workpieces to be joined by means of the rivet pin is then guaranteed. The means for firing the rivet and means for pulling the rivet can be powered pneumatically, hydraulically, magnetically, electrically, piezoelectrically or with use of explosive means.

The device according to Claim 2 offers the advantage that the reliability of the firing process and with that the reliability of the riveted joint itself is heightened by the interposition of a cylindrical striking member between the firing bolt and the rivet. The striking member can thus be made up of a first segment of which the diameter is adapted to the diameter of the firing channel and a second segment of which the smaller diameter is adapted to the diameter of the rivet pin, and particularly can be of approximately identical diameter up to 1.5-times the diameter of the rivet pin.

The device as in Claim 3 offers the advantage that the reliability of the firing process is further heightened by the centering device which may be synclinal and is adapted to the end of the rivet pin turned toward the striking member. Of particular importance, the traditionally desirable rectangular alignment of the rivet pin in relation to the workpieces to be joined and the corresponding guiding of the rivet during the firing process is guaranteed.

The device according to Claim 4 has the advantage that the striking member is already engaged on the rivet pin when the firing bolt impacts on the striking member. Thus any damage,

especially bending, of the rivet pin and of the striking member because of an impact of the striking member on the rivet pin is reliably prevented. Furthermore a falling of the torn-off rivet pin into the firing channel is thus also prevented, and the device can be operated in any setting, especially in that rivets can even be set up facing upward.

The device according to Claim 5 offers the advantage that the movement of the striking member at the end of the firing process is smoothly suppressed by the flexible buffer element and especially does not impinge on the end of the firing channel which is preferably of metallic configuration. The service life of the device is thus significantly increased. The buffer element preferably engages on an annular shoulder at the end of the firing channel which is formed by an opening in the firing channel, and the buffer can for example be configured as helical spring, disk spring or rubber or plastic washer.

The device of Claim 6 offers the advantage that the firing channel can be made easily accessible as a result of the two-part configuration of the firing channel formed by a hollow piston and a connecting member, which preferably are screwed together, and especially in that case the striking member can be exchanged when necessary.

The device according to Claim 7 offers the advantage that not only is the guiding of the rivet pin during the firing and pulling process obtained through the end piece, but that the end piece simultaneously executes a spreading of the clamping jaws during the firing process and with that allows a friction-free passage of the rivet pin and if necessary of the striking member through the clamping jaws during the firing process. Any damage to the clamping jaws and potentially to the striking member is simultaneously and reliably prevented by the rivet pin during the firing process. Also the introduction of a new rivet is simplified by the spreading of the clamping jaws. The second flexible element can be configured as a helical spring. Alternatively to that for

example a disk spring or a rubber or plastic washer can be used.

The device according to Claim 8 offers the advantage that by having the piston, joining member and clamp sheathing connected with one another, preferably by being screwed together with one another, a pulling of the rivet pin by means of the stress of the pressure of the piston counter to the force effect of a flexible element, preferably a helical screw with high elasticity constant, a reliable pulling of the rivet and with that a reliable production of the riveted joint are guaranteed. The pressure is preferably applied by using hydraulic pressure in order to generate the required high pressure forces.

The device as in Claim 9 offers the advantage that the device requires only one auxiliary connection, which is a compressed air connection. The preparation of the hydraulic pressure occurs through a pneumatic/hydraulic pressure converter. The rivet is fired pneumatically; the rivet is pulled off hydraulically. The entire riveting process including firing and pulling is controlled by a three-stage pneumatic switch element. The pneumatic/hydraulic pressure converter the same as the rapid evacuation or pressure release valve is preferably mounted in a handle of the device.

A rivet is described in Claim 10 for use in the device according to the invention. Here it is proven advantageous that the rivet jacket be connected securely with the rivet pin, preferably by being extruded thereon. Thus it is assured that the rivet pin will not be moved or at least will not be moved remarkably relative to the rivet jacket especially during the firing process. This is especially advantageous with use of the rivet in a device according to the invention, since with the device of the invention the means for firing the rivet act on the rivet pin. The rivet pin is preferably of steel or stainless steel. The rivet jacket can likewise be of steel or stainless steel or alternatively can be of an aluminum or copper alloy.

The rivet of Claim 11 offers the advantage that by the shaping of a point, penetration of the workpiece is possible even with low firing power. The point can thus be configured conical or if desired can be ogival, and more particularly the point can also have one or more cutting edges. The point angle configuration is preferably in a range of between 30 and 60°.

The rivet of Claim 12 has the advantage that a total of four cutting edges are formed by the pyramid configuration, which simplifies the penetration of workpieces.

The rivet as in Claim 13 has the advantage that cooperation with the centering device on the striking member is specifically guaranteed by the tapering second end of the rivet pin. A configuration of the second end in the shape of a pyramid is advantageously obtained by suitable separation of a rivet pin from a rod-shaped starting material.

The rivet according to Claim 14 has the advantage that by the provision of catching means directed toward the point of the rivet, any relative movement of the rivet pin in relation to the rivet jacket especially during the firing process of the rivet is reliably prevented. The catching means then can for example be realized by pins extending radially and distributed around the periphery of the rivet pin or by partial segments of the rivet pin which are truncated conically-shaped, arranged one behind the other in axial direction, and produced by rollers.

Other advantages, features and individual points relating to the invention are disclosed in the dependent claims as well as the following description with reference to the drawings showing one exemplary embodiment in some detail. Thus the selected features indicated in the claims and in the description can be protected individually in turn in and of themselves or in any desired combination considered as relating to the invention.

Fig. 1 shows a section through the head part of the device according to the invention,

Fig. 2 shows a section through the handle of the device according to the invention,

Fig. 3 shows a diagrammatic and partially cutout view of the entire device according to the invention, and

Fig. 4 shows a rivet for use in the device according to the invention.

Fig. 1 shows a section through the head part of the device according to the invention, which device is responsible for the firing and pulling of the rivet. The housing 1 of the device is represented at the right edge of the drawing, on which housing with use of a first packing O-ring 2 and a glass shield 24 the first cylinder 22 is screwed on by means of cylindrical screw 6 and supporting disks or washers 23. Likewise on the right edge of the drawing is represented the pneumatic cylinder 58 with the firing bolt 25 and the first buffer 50. Firing channel 70 extends in axial extension of firing bolt 25 and is formed by the centering member 45, the hollow piston 20 and the joining member 18. Piston 20 is screwed together with joining member 18 and is connected with the centering member 45 by a close adaptation of the play and under the effect of force from the third helical spring 8 configured as the third flexible element. Piston 20 is supported by means of third helical spring 8, which is supported at one end on the glass shield 24 and on the other end on centering member 45, prebiased in the direction of the rivet 14 represented at the left edge of the drawing.

Piston 20 is guided in first cylinder 22 by a guiding ring 13 and a first packing/sealing combination 12 and is sealed. On hydraulic connection 69, hydraulic power fluid is guided through an annular groove and corresponding bores into the first guide bushing 26 on a retaining ring 5 and into the hollow cylindrical volume between first cylinder 22 and piston 20, and piston 20 can be moved with corresponding pressure stress application of for example 200 Bar counter to effect of third helical spring 8 in first cylinder 22. Another hydraulic connection of first

cylinder 22 is plugged blind by the first screw 56. Piston 20 is guided and sealed by a second seal-forming combination 11 and a third O-ring 10 arranged axially adjacent to that arrangement on the rivet-side end of first cylinder 22. The seal-forming combinations 11, 12, 35 are of multiple parts and have a plastic part with a packing washer and a O-ring mounted thereunder.

Piston 20 is screwed together with the joining member 18 with use of a locknut 19. Into firing channel 70 formed by aligned boreholes in piston 20 and connecting piece 18 is guided a striking member 21, which is prebiased in the direction of rivet 14 by the first helical spring 51 embodied as first flexible element. First helical spring 51 is thus supported in the direction of housing 1 on an annular shoulder formed in the firing channel by piston 20 and is supported in the direction of rivet 14 on striking member 21. Striking member 21 at its end turned toward first helical spring 51 likewise has an annular shoulder formed by building up of a cylindrical extension with a small diameter, on which is supported first helical spring 51.

Striking member 21 can be configured of one or more pieces, especially of two pieces. In the case of a two-piece configuration, striking member 21 can consist of a jacket and a pin introduced into the jacket and connected securely with it, which pin has a smaller diameter, a greater length and a higher flexibility module and/or a greater hardness than the jacket. The secure connection between jacket and pin can be executed for example by welding, extrusion or by use of adhesive. The diameter of the jacket is adapted to the diameter of firing channel 70, while the diameter of the pin is adapted to the diameter of the rivet pin 14b.

In the position shown in the drawing, striking member 21 engages on a buffer element 49 arranged at the end of firing channel 70. Firing channel 70 is open through a borehole in joining member 18 to rivet 14, whereby in the exemplary embodiment shown in the drawing the striking member 21 has a first segment 21a of which the diameter is adapted to the diameter of firing

channel 70 and by means of which striking member 21 is guided in firing channel 70, and also has a second segment 21b, of which the smaller diameter is adapted to the diameter of the bore in joining member 18 or to the diameter of rivet pin 14b.

Joining member 18 is sealed in and guided within a guiding jacket 16 screwed together with first cylinder 22 with a second O-ring 9 inserted in an annular groove. Furthermore a clamp sheathing 4 is screwed together with joining member 18, which sheathing surrounds clamping jaws 3 arranged around rivet pin 14b and likewise is guided into the guiding sleeve 16. Clamping jaws 3 are spread at their end turned toward housing 1 by means of a pressure sheathing 17, which is prebiased under the effect of a second helical spring 7 arranged between pressure sheathing 17 and joining member 18 in the direction of rivet 14, and at its end turned toward rivet 14 is spread apart by means of an end piece 15 screwed into guiding sleeve 16. The spreading then is executed by form-locking contact of conical contact surfaces of clamping jaws 3 and pressure sheathing 17 or end piece 15.

Second segment 21b of striking member 21 projects into the position represented in the drawing through the bore of joining member 18 and a bore in pressure sheathing 17 until it reaches between clamping jaws 3 and engages on rivet pin 14b of rivet 14. At its end adjacent to rivet pin 14b, second segment 21b is shaped in a synclinal depression serving as centering device for rivet pin 14b.

Guiding sleeve 16 is surrounded by a centering sleeve 54, which has an opening in alignment with the borehole in end piece 15 to receive rivet pin 14b. Centering sleeve 54 is tightly connected over first screw 52 and centering sleeve 54 or to the second rod 57, preferably welded thereto, nuts 53 connect with a first rod 55 and a second rod 57, while rod 57 acts on a switch element of the device in such a manner that the firing process cannot be triggered until the

centering sleeve 54 is moved by a suitable contact force on the device with contact of rivet 14 to the workpieces to be joined as well as to centering sleeve 54, moving axially in the direction of housing 1 through guiding sleeve 16 and engages thereon. Thus both the risk of injury by firing of a rivet without suitable contact on a workpiece and also blank firing and the risk of damage to the device connected therewith are effectively minimized.

Fig. 2 shows a section through the handle 71 of the device of the invention. Through the compressed air connection 68 the device is supplied with compressed air for example at 7 Bar pressure. The process of firing and pulling is controlled by means of a pneumatic switch element surrounding the firing valve 59, pulling valve 60 and outlet 61. The active pneumatic/hydraulic pressure converter during the pulling of the rivet is triggered by means of a not shown connection between pulling valve 60 and input connection 67 in the covering 34 with compressed air. The not shown connection can for example be realized through compressed air tubes guided outside of the handle or by compressed air tubes or compressed air channels guided within the handle.

Covering 34 furthermore surrounds a rapid evacuation valve, which includes a sliding seal 48 and a member 46 sealed by means of a ninth O-ring 64 and having an axial borehole. On the output side of the rapid evacuation valve is provided a screen 47 secured with a second security ring 63, in order to prevent contamination of the rapid evacuation valve. Connection of the rapid evacuation valve with the second cylinder 32 of the pneumatic/hydraulic pressure converter is provided through a borehole in covering 34. Covering 34 is connected with use of a sealing flange 33 screwed together with it and seventh and eighth O-rings 39 and 62 with the second cylinder 32.

Within second cylinder 32 is arranged a pneumatic piston 31 which is sealed off from the wall of second cylinder 32 by means of a sixth O-ring 38 introduced into an annular groove. A piston

rod 27 is connected with pneumatic piston 31, and with use of a third sealing combination 35 and a fifth O-ring 37 piston rod 27 moves through a flange 30 and enters into a hollow space 66 filled with a hydraulic fluid. Piston rod 27 is also guided by a guiding bushing 29 arranged between guiding flange 30 and handle 71. With an upward movement of pneumatic piston 31 and concomitantly with the piston rod 27 movement being reversed, the pneumatic pressure at the input connection 67 is converted into hydraulic pressure in hollow space 66. The hydraulic pressure is guided through output connection 65 to the hydraulic connection 69 shown in Fig. 1. The not shown pressure guide on the hydraulic side can in turn for example be guided by pressure lines from outside the handle or the device can be realized by pressure lines or pressure channels guided within the device.

Guiding flange 30 is screwed by means of the second screw 40 together with handle 71 with use of a fourth O-ring 36 and sealed tightly. At the same time by means of exterior threading, flange 30 is screwed together with the second cylinder 32. Furthermore an annular second buffer 44 is provided on flange 30 for the buffering of pneumatic piston 31 in the case of an upward movement.

The following functions take place during the production of a riveted joint : first of all as shown in Fig. 1 a rivet is introduced into the device until rivet pin 14b engages on striking member 21. In this state the firing process has not yet been triggered, since the centering sleeve 54 in the position shown in Fig. 1 does not yet release or disengage from the pneumatic switch element 59, 60, 61. Finally the device having rivet pin 14b is pressed against the workpiece to be joined. Then rivet pin 14b is first introduced counter to the effect of the first helical spring 51 by the clamping jaws 3 in the opening of joining member 18 and thus the striking member 21 is pressed to the rear in firing channel 70. The striking head 14e of rivet sleeve 14a thus comes into contact with centering sleeve 54 and moves this sleeve with further pressing in the direction of guiding

sleeve 16, whereupon the pneumatic switch element 59, 60, 61 is disengaged by means of the first and second rods 55, 57.

During the operation of the first switch step, firing bolt 25 is slipped forward by centrifugal action and impacts on striking member 21, which then acts on rivet pin 14b and fires rivet 14 into the workpieces to be joined. The forward movement of striking member 21 is then buffered by the buffer element 49 within firing channel 70.

With further pulling through of the outlet 61 shown in Fig. 2, by means of the pulling-valve 60, the pneumatic/hydraulic pressure converter is acted upon with compressed air coming through input connection 67. The seal 48 thus engages on insert member 46 and frees the passage of compressed air on pneumatic piston 31, which is moved upward and builds up a pressure in the hollow space 66 over piston rod 27, and the pressure is fed through the output connection 65 to hydraulic connection 69 shown in Fig. 1.

The hydraulic pressure works on piston 20 and presses it counter to the force of third helical spring 8 in the direction of housing 1. Thus clamp sheathing 4 is also pulled in the direction of housing 1 and clamping jaws 3 engage rivet pin 14b tightly and tear it rearward to a predetermined break point. With release of outlet 61, the input connection 67 shown in Fig. 2 is without pressure, whereupon the seal 48 of member 46 drops away and the passage for the compressed air is released from second cylinder 32 through member 46 and screen 47 leading to the outside environment. Second cylinder 32 is then without pressure. Under the effect of third helical spring 8, piston 20 in its original setting is pressed in the direction of rivet 14 and through hydraulic connection 69 and output connection 65, piston rod 27 and along with that pneumatic piston 31 is moved back into its bottom original position. Simultaneously by the movement of piston 20 in the direction of rivet 14 by means of second segment 21b of striking member 21 the

torn away rivet pin 14b is thrown out forward by clamp sheathing 4 and guiding sleeve 16. The device is now ready for the insertion of another rivet and for the repeated production of a riveted joint.

The mechanism of pneumatic switch elements 59, 60, 61 and of second rod 57 arranged in working connection with the switch is designed so that firing bolt 25 following an act of firing preferably returns to its original setting and multiple triggerings of the pulling process without cyclical firing processes is possible, as long as the machine has not been removed from the workpieces to be joined. This advantageously allows for multiple pullings of a rivet which has been fired in and therefore increases both the reliability and the operational security of the device.

Fig. 3 shows a diagrammatic and partially sectioned total view of the device of the invention. The position of rivet 14 which is shown in relation to centering sleeve 54 and therefore thus on the head of the device corresponds to the representation of Fig. 1. The position of pneumatic piston 31 in handle 71 corresponds to the representation in Fig. 2. The compressed air conduit 72 is represented by a broken line between the pulling valve 60 and the input connection 67. The hydraulic pressure line 73 is represented by a broken line between output connection 65 and hydraulic connection 69.

Fig. 4 shows a rivet for use in the device of the invention. Rivet 14 is constructed in two parts and has a rivet jacket 14a and a rivet pin 14b. Rivet pin 14b is provided at its first end directed to the workpieces to be joined with a point 14c and with cutting edges 14d. Having a pyramid shape of the first end of rivet pin 14b has been shown as especially advantageous, whereupon all four cutting edges 14d are formed. Rivet pin 14b is surrounded in segments by rivet jacket 14a, whereby rivet jacket 14a on its end more distant from point 14c is configured as mushroom-shaped and forms a striking head 14e. At the end 14g opposite this point 14c rivet pin 14b is

likewise configured preferably in pyramid shape, in order to guarantee reliable centering in relation to the striking member 21.

With the firing of rivet 14, rivet pin 14b together with rivet jacket 14a is driven sufficiently far into the workpieces which are to be joined until striking head 14e engages on a workpiece to be joined. In order to prevent penetration of rivet pin 14b, rivet pin 14b has catching means in the area of rivet jacket 14a directed in the direction of the point 14c of rivet 14. These means can for example be formed by saw-toothed, rolled-in annular grooves, whereby the sawtooth shape is aligned so that during the firing of rivet 14 rivet pin 14b hooks into the rivet jacket. In the area of this catching means rivet jacket 14a is connected tightly with rivet pin 14b, for example is extruded, soldered, cemented or welded with it. Therefore rivet pin 14b in the area of rivet jacket 14a has a predetermined break point 14f, from which rivet pin 14b tears away during pulling of rivet 14.